SUMMARY OF FINDINGS

The following findings regarding commercial utilization of the ISS were developed during the course of this study. Our efforts took into consideration the trends related to commercial space, the market research reviewed and the input of the CSVAT.

Market Research Data Limited

Very little relevant market research for commercial use of the ISS was found during the course of this study. The commercial space market research conducted by the private sector is largely unrelated to the science and technology mission of the ISS. Outside of a few proprietary commercial research reports performed by aerospace companies for very narrow applications of existing space assets, we were unable to acquire or identify any significant body of commercially-funded market research on the value of the ISS for private sector use.

Low Levels of Private Sector Interest

To date, the level of private sector financial involvement in space-based research has been insignificant in comparison to the levels of government-sponsored research. Since the mid-1980's, NASA has attempted to foster industry collaboration with government and university research through the Centers for the Commercial Development of Space (CCDS); the former CCDS' are currently called the Commercial Space Centers (CSCs). According to CSC published data, there are a combined total of 264 CSC affiliates, 183 of which are commercial in nature. The commercial partners of the CSCs have invested $430 million in commercial space research. Even with these agreements between the government, industry and academic entities, the economic success of the CSCs in the commercial application of space research has been limited, due primarily to the impediments highlighted in this report.

The technology adoption curve describes the behavior of consumers (companies and/or individuals) when provided with a new enabling technology or innovation. A recently-published article summarizes the process and issues surrounding technology adoption; its relevance to assessing the ISS market

[3]"One of the most profitable strategies firms follow is that of bringing innovative products to market and gaining first-mover advantage over competitors. The need to provide innovative products is increasingly felt in light of global competition, more parity products, shorter product life cycles, and increasingly sophisticated and knowledgeable consumers. Yet, innovations are also risky; some succeed and many fail (Cooper 1993). One important determinant of an innovation's success is consumers' beliefs about the viability of the innovation; beliefs that are likely to evolve as the innovation changes and consumers move through the stages of the adoption process. While not necessarily limited to markets for high-tech products, these concepts are particularly appropriate in high-tech markets because of the effect of rapidly evolving technology on product markets and consumer purchase decisions.

Much research has studied both innovations and the consumers who adopt them. Adoption research, based primarily on the work of Rogers (1962), has focused on general reasons for adoption at an abstract level. Other researchers have examined the characteristics of adopters, trying to answer such questions as what distinguishes the "innovators" from the "laggards." Perhaps the most prolific stream of research has focused on timing, or how fast the innovation will diffuse, and factors such as price and advertising, which affect timing. The Bass (1969) model and the numerous extensions that have followed exemplify this work.

potential is clear.[3] Essentially, utilization of space as a research environment by commercial industry is still in the "early adopter" stage of its technology adoption curve. In order to move to the "mass market" stage of the curve, a significantly larger base of experience will need to be generated by industry and academia.

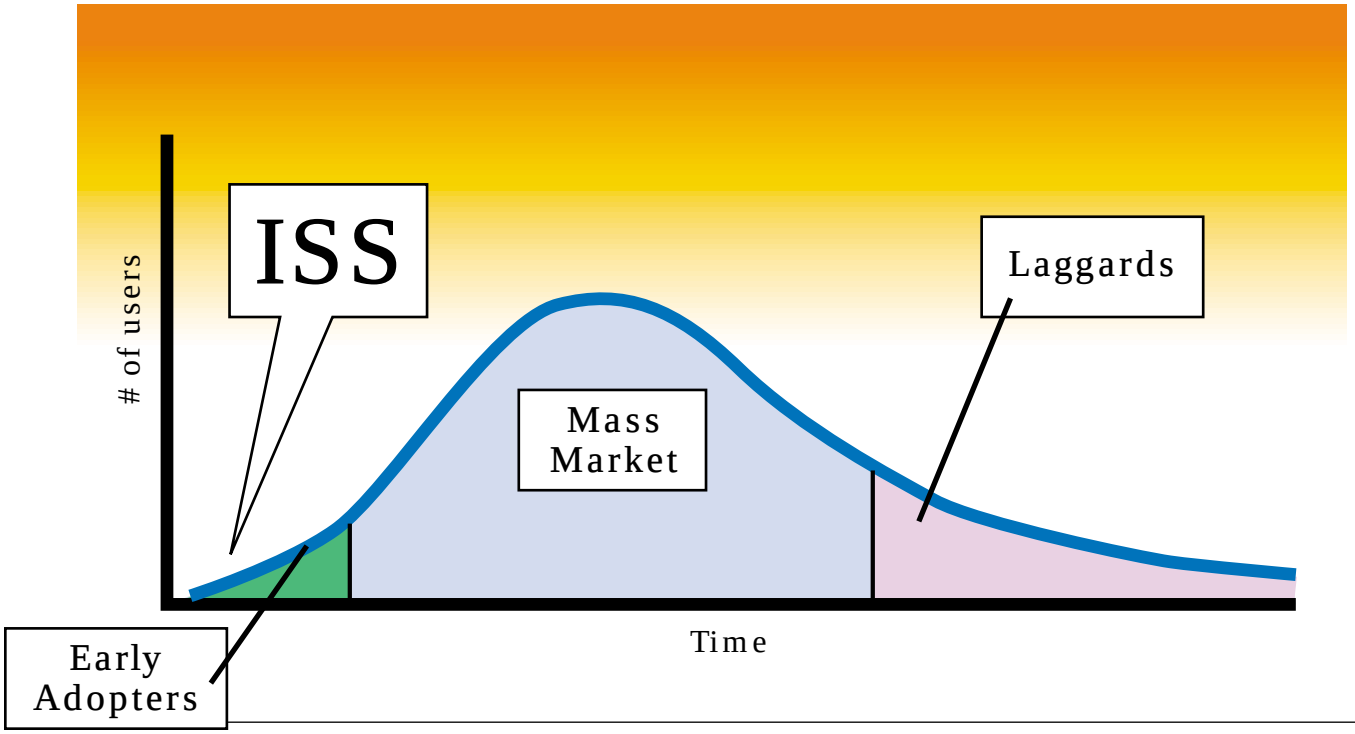
Figure 4 provides a graphical representation of the technology adoption curve and our assessment of the relative placement of the ISS within that framework.

Questionable Value of ISS Market Demand Forecasts

Conducting an objective market study to evaluate the potential commercial utilization of the ISS - given its current state of development (Figure 4) - is a difficult task. This is due to the embryonic nature of the markets which are being evaluated.

The ISS has been promoted as a platform for the development of new technologies, processes, or products to improve life on Earth and create new economic opportunities. The research environment provided by the ISS in LEO is characterized by a number of unique attributes, including extended duration microgravity, an ultra-vacuum environment, and a unique vantage point.

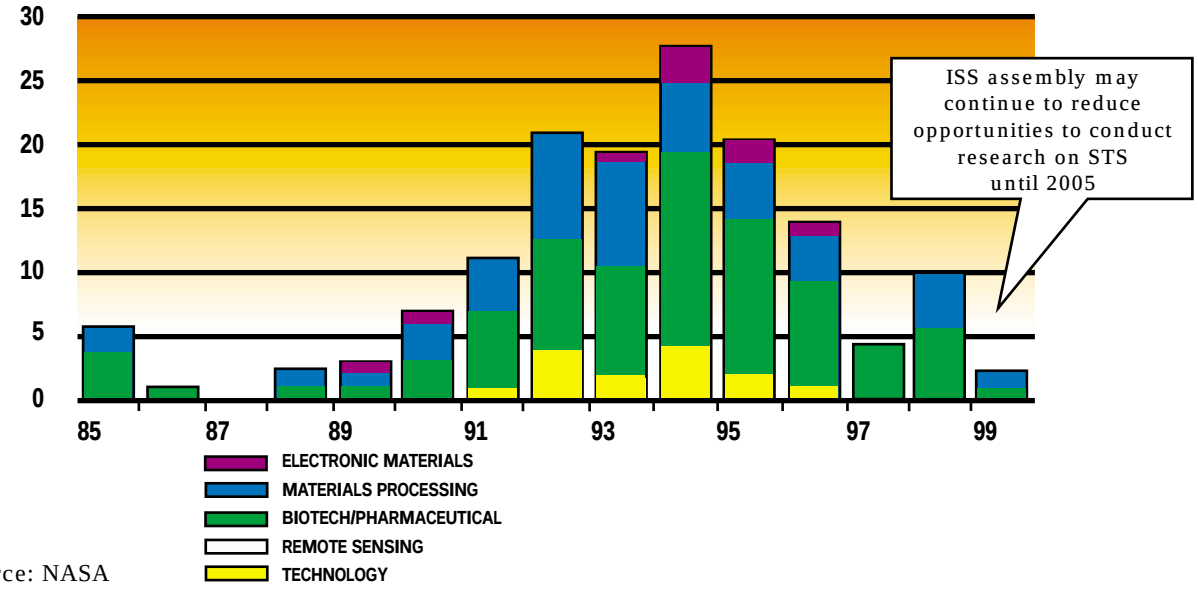
FIGURE 4: THE ISS AND THE TECHNOLOGY ADOPTION CURVE



Recently, there has been particular interest in "really new" products evidenced by special issues devoted to this topic by Journal of Marketing Research and Journal of Product Innovation Management in 1997. The practitioner community has seen an ever-increasing array of seminars and business press books on the topic. Of particular note are Geoffrey Moore's books, Crossing the Chasm (1991) and Inside the Tornado (1995). Moore blends Rogers' work with his experience to offer an "updated" version of the adoption cycle suited for

Since 1985, approximately 150 commercial flight experiments have flown on the Space Shuttle. Unfortunately the availability, and therefore use, of the Space Shuttle for commercial research has been declining for the past four years (Figure 5). This problem will continue unless ISS flights include significant commercial payload opportunities.

FIGURE 5: ANNUAL COMMERCIAL EXPERIMENTS FLOWN ON STS



Source: NASA

Given that the current level of private sector involvement in human space is still quite small, it may be necessary for government to maintain its dominant role in space-based R&D for the foreseeable future. If at some point the perceived value of space-based R&D by industry is great enough to warrant private-sector participation, rapid uptake of the available capacity of the ISS would likely follow.

high-tech markets. To succeed, Moore stresses that firms must understand and respond to the needs of different consumer groups at different stages of the adoption cycle. Importantly, "mainstream" market consumers have needs beyond the product itself including references from other adopters, established standards, lots of support, and a preference for large, well-established companies (Moore 1991:13). The attractiveness of an innovation is also affected by factors beyond the characteristics of the product itself, for example, the reputation of the firms offering the product, who is using the product already, and, for many technical products, whether a uniform "standard" has been set. Moore (1991) illustrates this well when he discusses market pragmatists-those buyers of high-tech products who buy during rapid market growth-as caring about "the company they are buying from, the infrastructure of supporting products and system interfaces, and the reliability of the service they are going to get" (p. 43).

It is important to note that attractiveness can evolve over a product's life. A shortcoming of much research studying innovations is that the innovation is assumed to remain unchanged over its life. It is more realistic to recognize that the innovation changes over time and that, as a result, consumer perceptions and evaluations can also change.

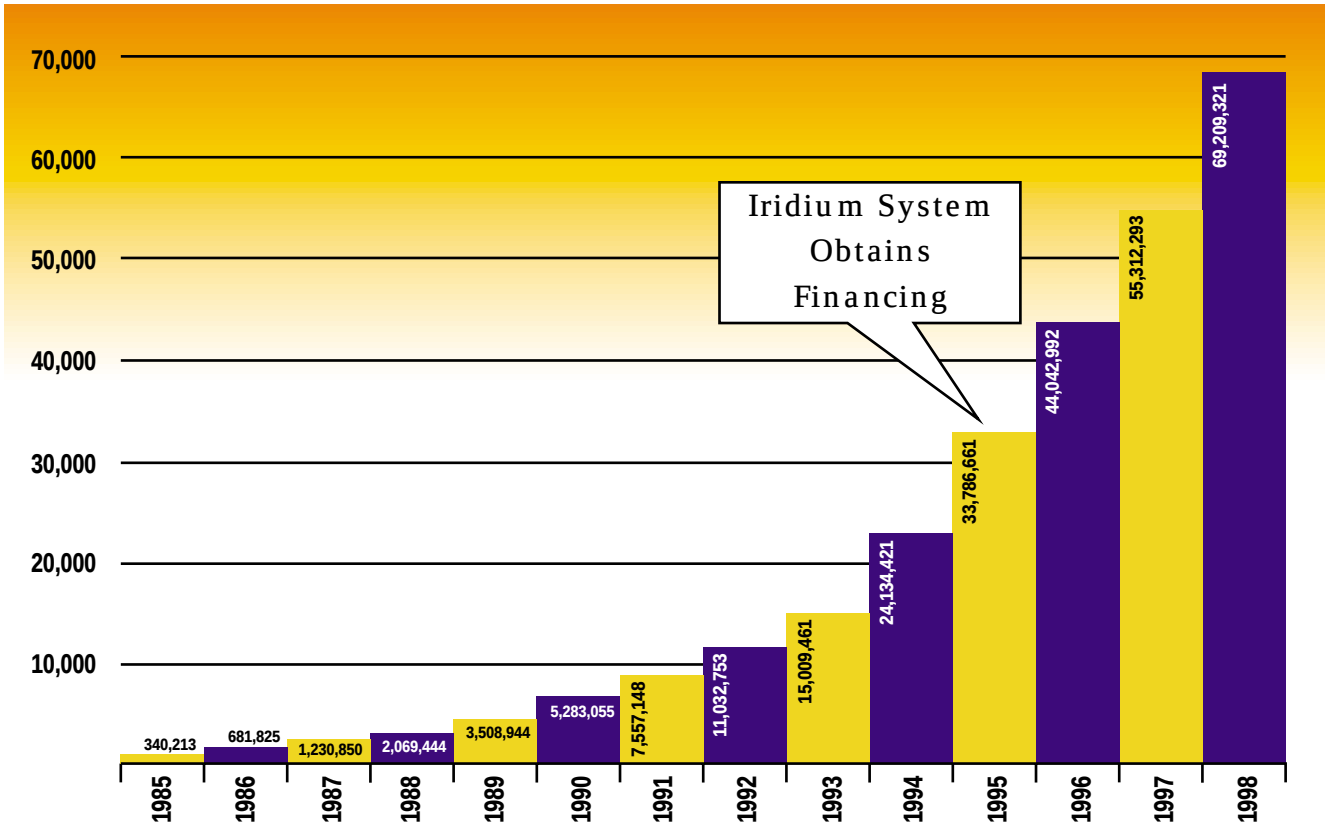
It is possible for a consumer to perceive a product category as attractive but have a low likelihood of adoption due to lack of immediate personal need. However, higher attractiveness should generally increase the likelihood of adoption because it implies the consumer recognizes the potential utility and viability of the product category. Conversely, it is unlikely a consumer would adopt a product with low attractiveness."

Boyd, Thomas C; Mason, Charlotte H : "The link between attractiveness of "extrabrand" attributes and the adoption of innovations" Journal of the Academy of Marketing Science, Summer 1999

Extended duration human-tended microgravity – as the primary capability offered by the ISS – is an essentially undeveloped technology in the earliest stages of research, with no analogous capability on Earth. As a result, it is questionable to attempt to forecast - with any accuracy - market demand for such a new capability. Similarly, it would have been highly unlikely for Iridium to obtain private sector financing in 1980 due to the lack of a developed terrestrial market for wireless telecommunications services. Early in the development of Iridium, cellular adoption rates were relatively low. As the cellular market matured and the operating economics of the terrestrial wireless business became clearly understood, the business case for a space-based alternative - Iridium - could be closed (Figure 6).

As recent events surrounding Iridium have shown, even when the financial sector backs space-based businesses which either replace or supplement a terrestrial capability, there is no guarantee of profitability.

FIGURE 6: CELLULAR ADOPTION RATES AND TIMING OF IRIDIUM FINANCING

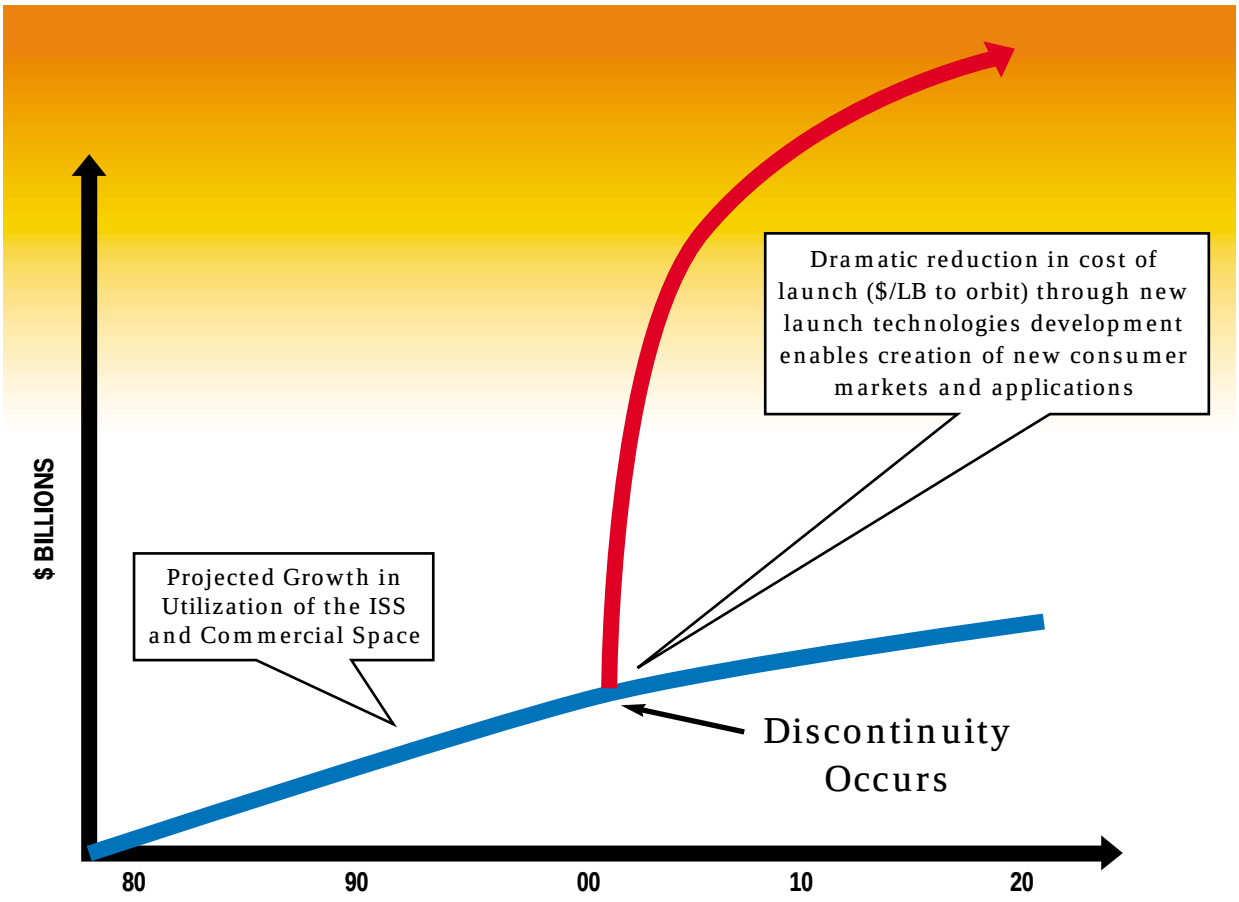


Impact of High Launch Costs

The cost of access to the ISS via shuttle is currently prohibitive to the private sector. Commercially backed R&D will not occur if required to pay $7,500 to $10,000/lb for transportation to the ISS. Until a substantial lowering of launch costs occur, this fundamental stumbling block to space commerce will remain.

A number of papers have been produced by space advocacy organizations proposing many new commercial activities in space. These studies project significant near term markets for space commerce (e.g. space tourism), capable of generating billions of dollars of revenue for private sector space companies. Unfortunately, as with space R&D markets, most humans-in-space oriented commercial markets require a radical lowering of cost per pound to orbit. (Figure 7). Until the costs of space access are lowered, the relevance of these markets to the commercial utilization of the ISS in the near term, is limited. Therefore, a primary NASA goal should be to aggressively nurture a variety of advanced RLV technologies in order to lower launch costs as rapidly as possible, thus enabling positive market discontinuities.

FIGURE 7: NOTIONAL EFFECT ON MARKET OF SIGNIFICANT LAUNCH-COST REDUCTION



Entertainment, Education and Advertising Promising

Based on our research, the earliest pre-assembly-complete opportunities for significant revenue generating commercial activity on the ISS may be found in the fields of entertainment, education and advertising (e.g. licensing, for-profit educational programming, corporate sponsorship, etc.). The public has long been interested in space exploration and human spaceflight, and the ISS represents an opportunity to further that excitement. The last two decades have witnessed a relative decline in attention paid to space activities due to the perception amongst the population that space activity has become routine. Judging from the high levels of public interest recently witnessed in the Mars Pathfinder and John Glenn missions, it appears that this trend can be reversed. A strong uptick in public interest in space activities could allow significant opportunities for expanding commercial utilization of the ISS.

While entertainment, education and advertisement do not fall within the core science and technology mission of the ISS, they potentially offer a near-term revenue stream that could be used to offset the cost of longer-term R&D projects for which the ISS was designed. In addition, entertainment, education and advertisement uses of the ISS in the near-term will increase awareness of the ISS in the eyes of the commercial user community and, as a result, would have a positive effect on the overall level of commercial utilization of the ISS.

Long Term Prospects

In the long term, we believe that the ISS could see significant commercial demand for its R&D capabilities, as the results from early experiments reach commercial maturity and are successful in generating measurable financial returns for the private sector. If this private sector interest should outstrip the capabilities of the ISS, it would create the demand necessary for the development of privately financed orbital facilities thus completing the migration to pure commerce in space.